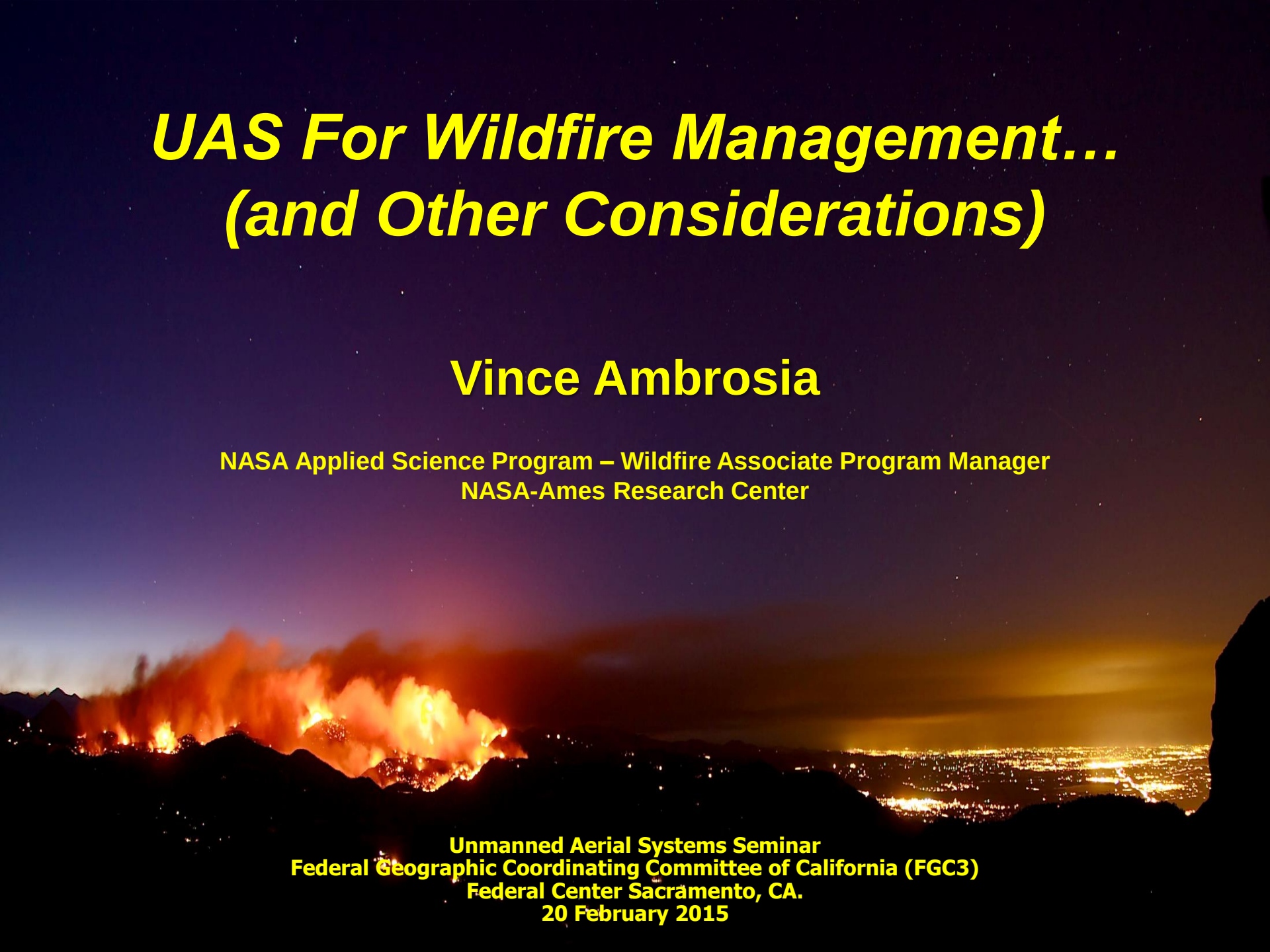


UAS For Wildfire Management… (and Other Considerations)

Vince Ambrosia

NASA Applied Science Program – Wildfire Associate Program Manager
NASA-Ames Research Center

Unmanned Aerial Systems Seminar
Federal Geographic Coordinating Committee of California (FGC3)
Federal Center Sacramento, CA.
20 February 2015

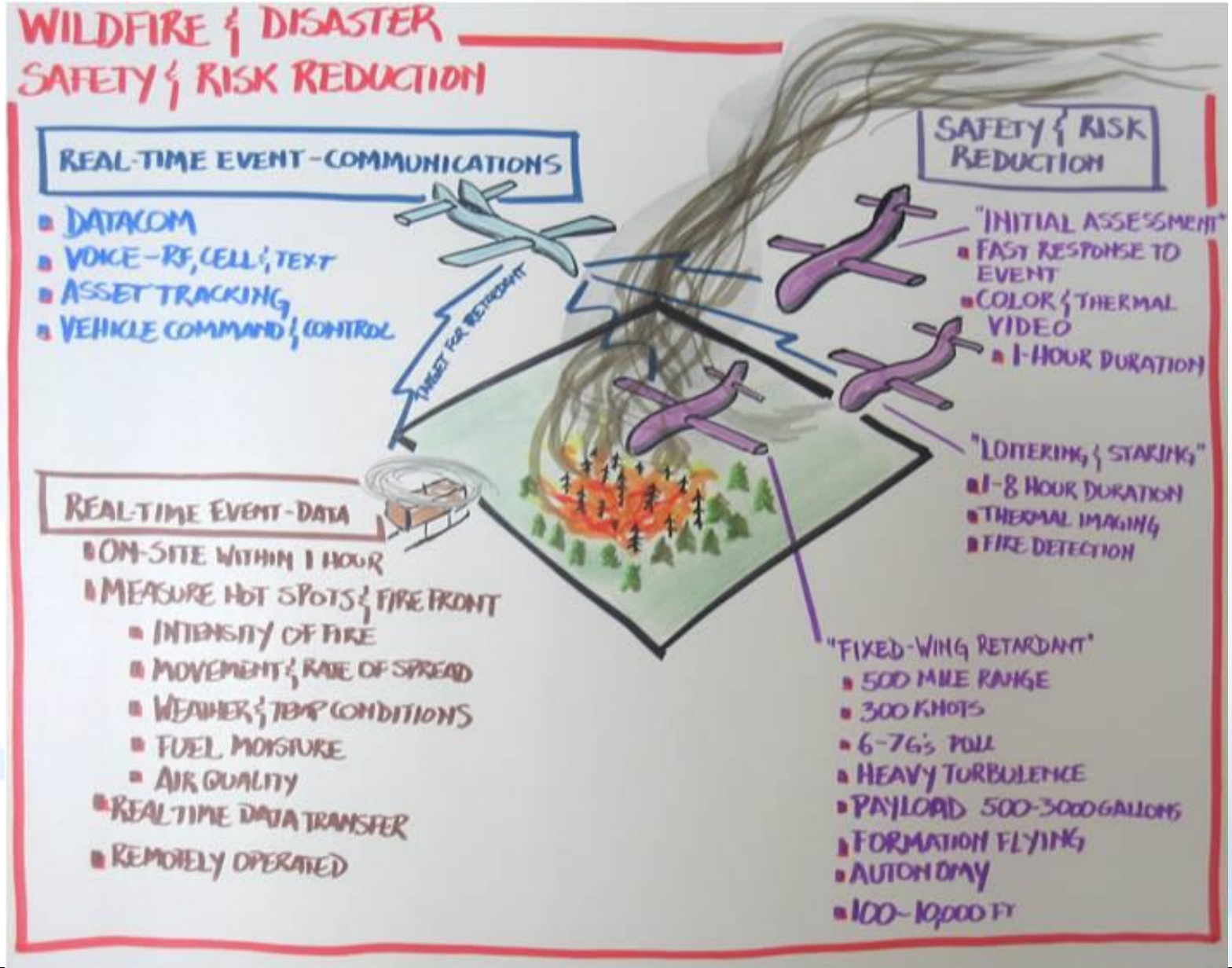
Talking Points

UAS in Support of Wildfire Observations

- UAS Fire Applications
- Strategic UAS Fire Applications (NASA Ikhana)
- Tactical (sUAS) Fire Applications
- sUAS Sensor Limitations and Projected Improvements
- FrankenEye – Repurposing sUAS for Science Support
- Points to Consider / Remarks
- Contact Information

Public Concern & Interest

Possible UAS Fire Applications



Two-Track Approach to Evaluating UAS

Large Platforms

STRATEGIC

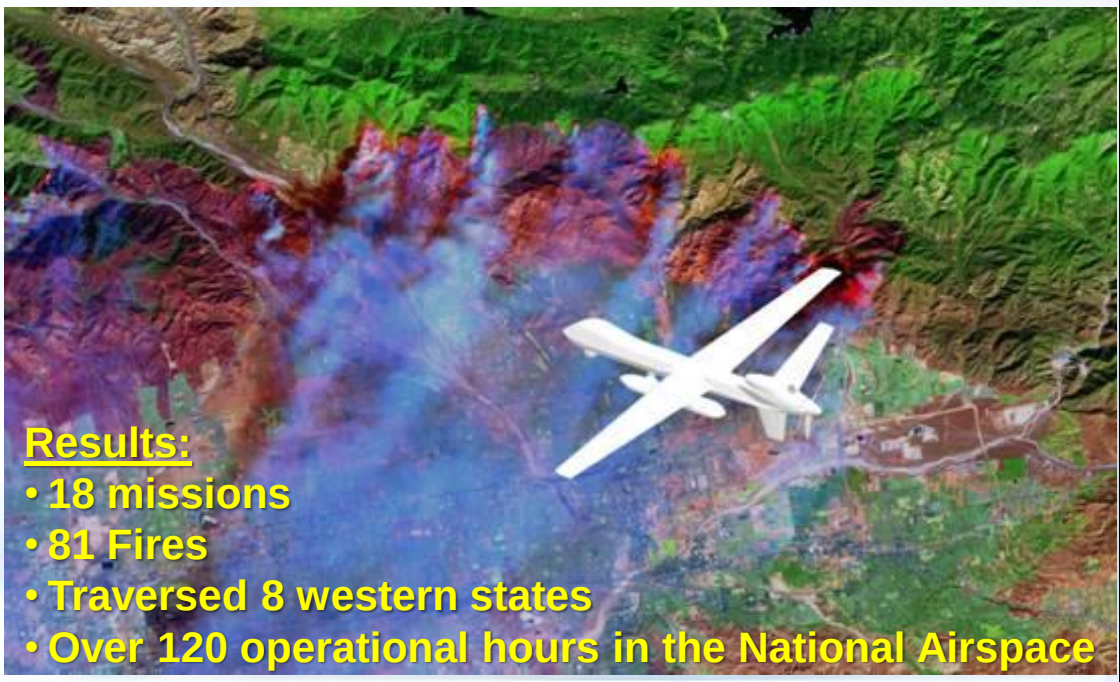
Small Platforms

TACTICAL

2007-2009 UAS Western States Fire Missions

- NASA/USFS collaboration via Wildfire Research Applications Partnership (WRAP)
- Missions conducted using NASA Ikhana UAS
  - Standard MQ-9 Predator B/Reaper w/o skyball

- Mission Plan:
  - One LE mission/week
  - 4-5 missions/summer
- Mission Durations:
  - ~20+ hours
- Flight Altitude Operations:
  - FL230 (23,000 feet MSL)



NASA Ikhana UAS Fire Imaging Missions

NASA Wildfire Support (2006-2011)

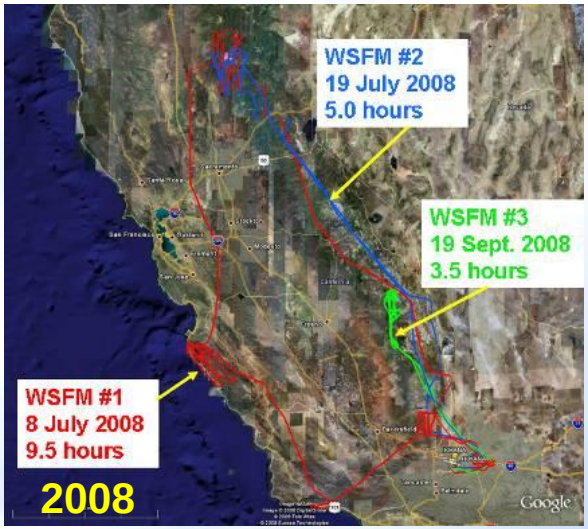
2006: Esperanza Fire

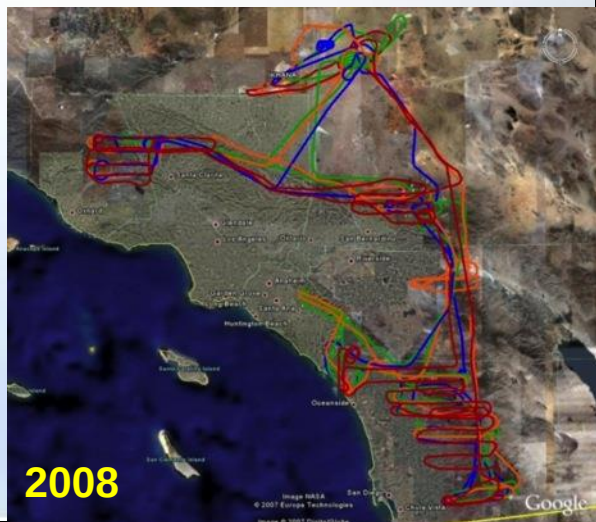
2007: Zaca, Tar, Babcock, Colby, Butler, North, Fairmont, Grouse, Lick, Bald, Moonlight, Jackrabbit (CA), Trapper Ridge (ID), Castle Rock (ID), WH (MT), Columbine (WY), Hardscrabble (WY), Granite Creek (WY), GW (OR), Big Basin (OR), Domke Lake (WA) South Omak (WA), So. CA Firestorm: Harris, McCoy, Witch, Poomacha, Horno / Ammo, Slide, Grass Valley, Buckweed, Ranch, Magic, Santiago, Rice

2008: Piute, Clover, Silver, North Mtn., American River, Cub Complex, Canyon Complex, Basin, Gap, Camp, Cascadel, Hidden

2009: Station and Piute Fires (post-fire assessment)

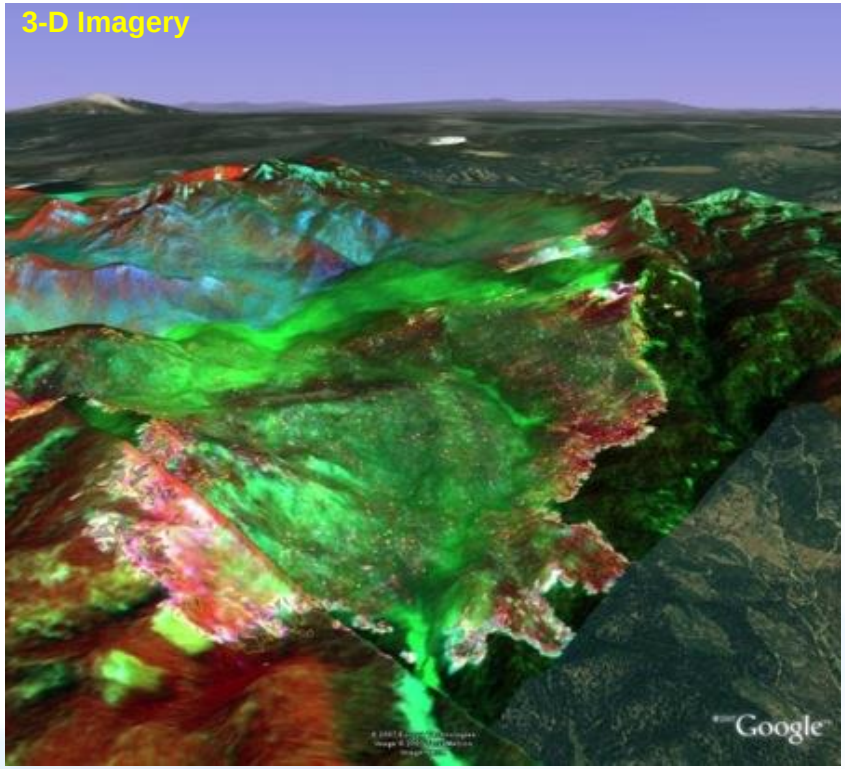
2011: Lion, Eagle, Great, Coe Prescribed Science Burn

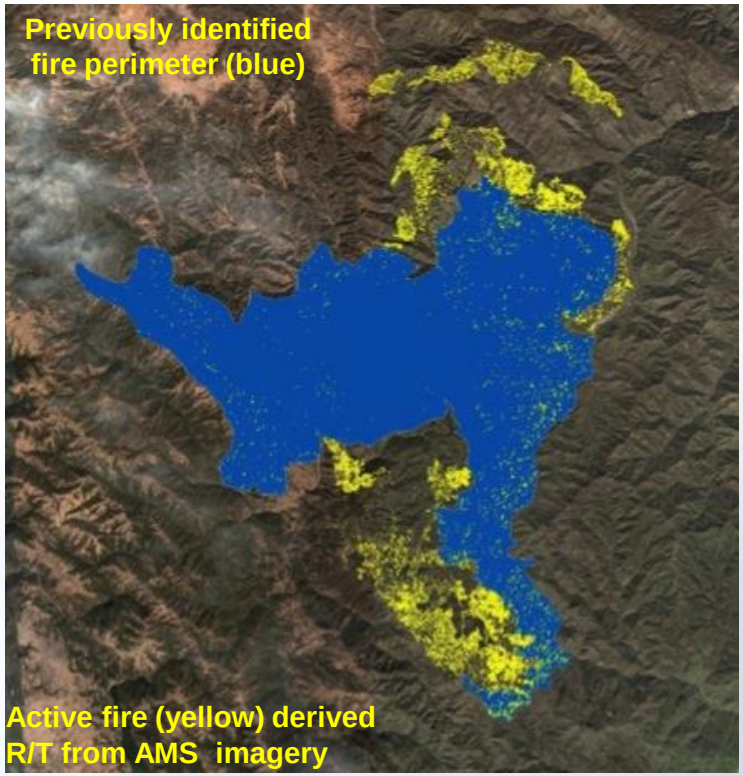




On-Board Sensor Product Generation

Provide adaptable, user-driven, automated, real-time products from an airborne sensor directly to disaster management personnel





Impact:
R/T data, visualized in simple format, allows time savings in resource allocation and cost savings in fire mitigation!

Tactical (sUAS) – Right Tool for the Right Job

Tactical (sUAS)

The situations where tactical UAS can support wildfire observations:

- Fireline Supervisors use to provide real-time photo / video and IR imagery in tactical situations;
- Direct support to fireline operations / hot-shot crews;
- Conditions where manned aircraft are undesirable (smoke, night, difficult terrain, etc.);
- Fire support by sUAS is required immediately;
- Ability to launch quickly;
- Mop-Up Operations / Spot Fire

First UAS (LARP) Fire Effort, 1961

ScanEagle Support AK Fires, 2010

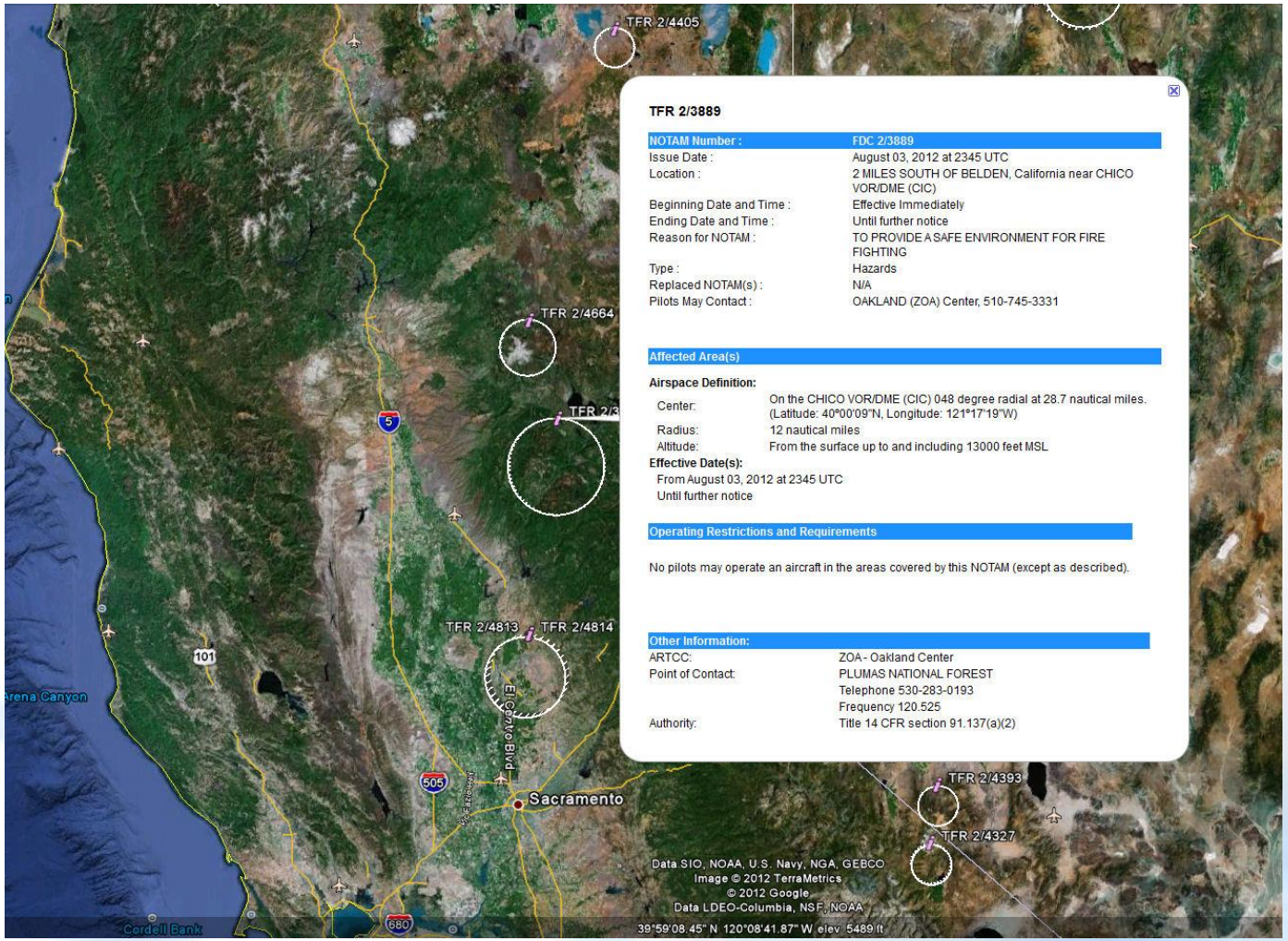
Considerations of Use of sUAS

There are a number of issues to consider when a resource manager / incident team member wants to employ UAS in their mission, including:

- Airspace Issues
- Sensor Capabilities
  - Use of Data (video / Stills?)
  - Data Formats
- FAA Regulations
- Safety Considerations
  - Weather
- Commercial vs. Public Use Aircraft
- Costs?
- Legal Issues (Privacy, Insurance, etc.)

Fire Airspace Issues

Large fires are usually designated with FAA-granted Temporary Flight Restrictions (TFRs) to control airspace around fires. Fire agencies and FAA manage those TFR areas.



TFR 2/3889

NOTAM Number :	FDC 2/3889
Issue Date :	August 03, 2012 at 2345 UTC
Location :	2 MILES SOUTH OF BELDEN, California near CHICO VOR/DME (CIC)
Beginning Date and Time :	Effective Immediately
Ending Date and Time :	Until further notice
Reason for NOTAM :	TO PROVIDE A SAFE ENVIRONMENT FOR FIRE FIGHTING
Type :	Hazards
Replaced NOTAM(s) :	N/A
Pilots May Contact :	OAKLAND (ZOA) Center, 510-745-3331

Affected Area(s)

Airspace Definition:

Center:	On the CHICO VOR/DME (CIC) 048 degree radial at 28.7 nautical miles. (Latitude: 40°00'09"N, Longitude: 121°17'19"W)
Radius:	12 nautical miles
Altitude:	From the surface up to and including 13000 feet MSL

Effective Date(s):

From August 03, 2012 at 2345 UTC
Until further notice

Operating Restrictions and Requirements

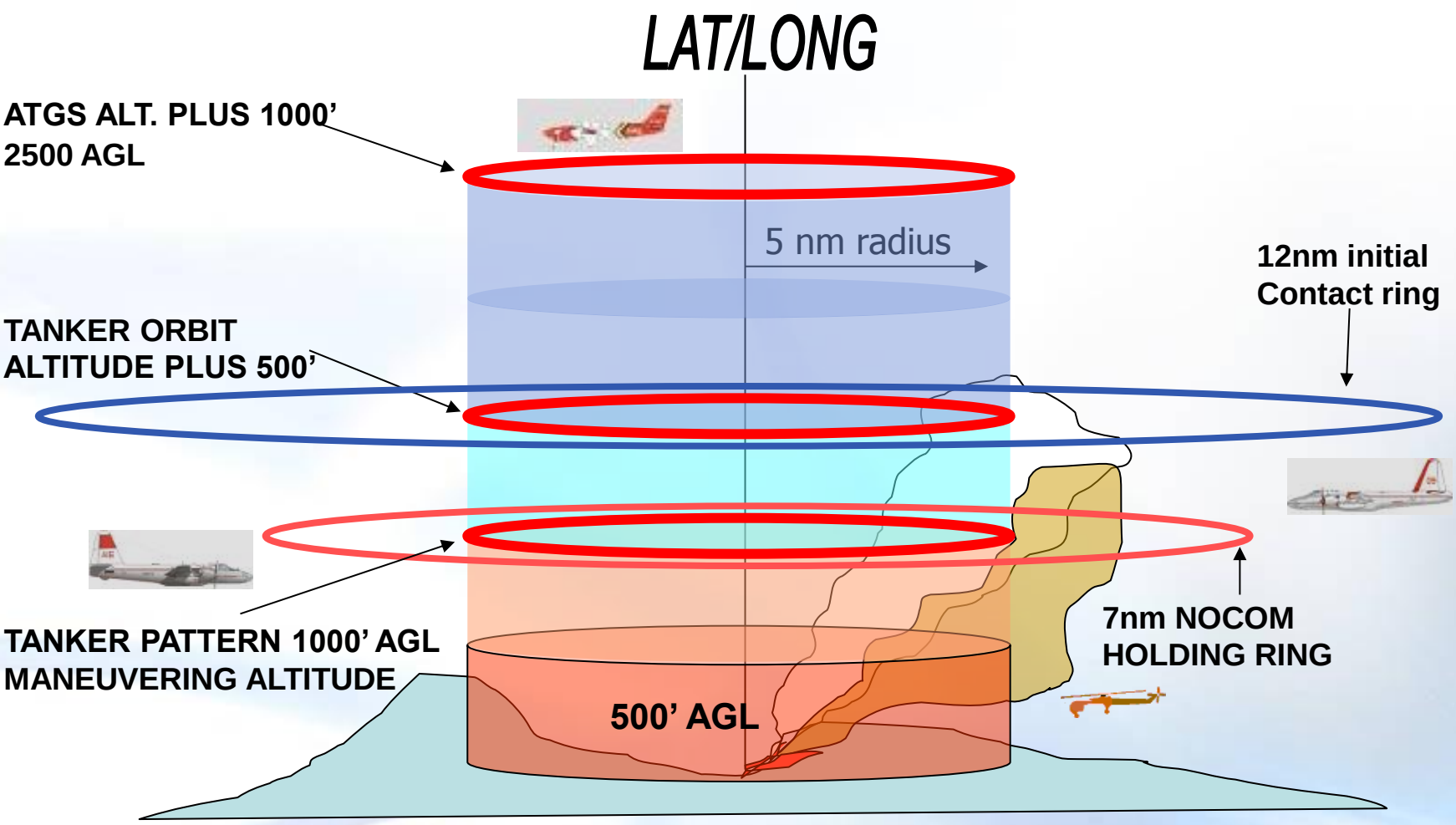
No pilots may operate an aircraft in the areas covered by this NOTAM (except as described).

Other Information:

ARTCC:	ZOA - Oakland Center
Point of Contact:	PLUMAS NATIONAL FOREST Telephone 530-283-0193 Frequency 120.525
Authority:	Title 14 CFR section 91.137(a)(2)

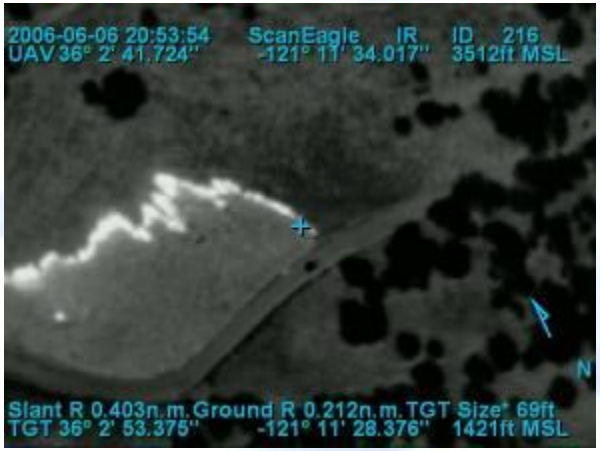
Fire Traffic Area (FTA) Environment

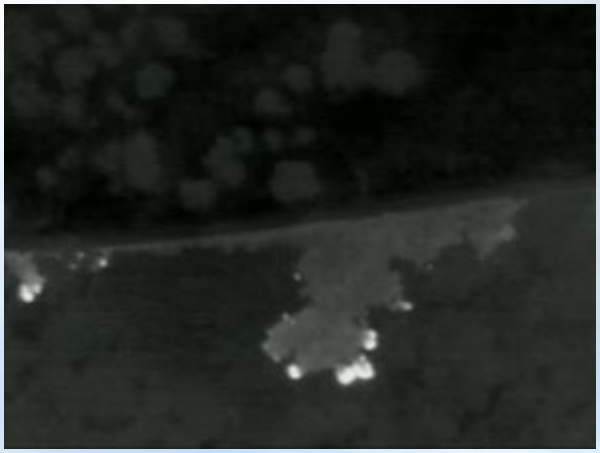
After obtaining a COA, there are additional challenges to using UAS on wildfires…



sUAS Fire Products

Near real-time full motion video of active fire areas

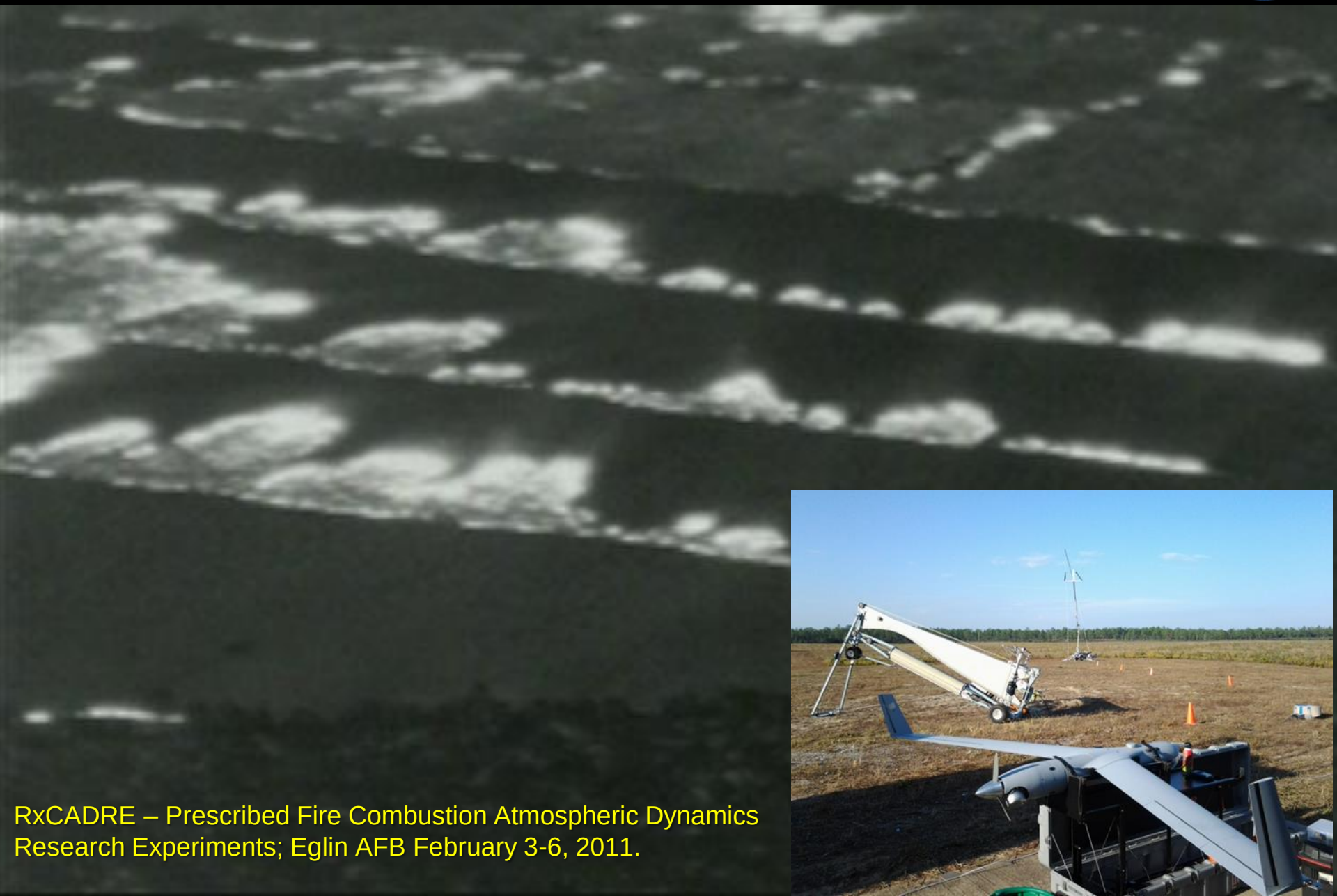




Scout TIR Imagery

RxCADRE – Prescribed Fire Combustion Atmospheric Dynamics Research Experiments; Eglin AFB February 3-6, 2011.

Scan Eagle Thermal Infrared (TIR)



RxCADRE – Prescribed Fire Combustion Atmospheric Dynamics Research Experiments; Eglin AFB February 3-6, 2011.

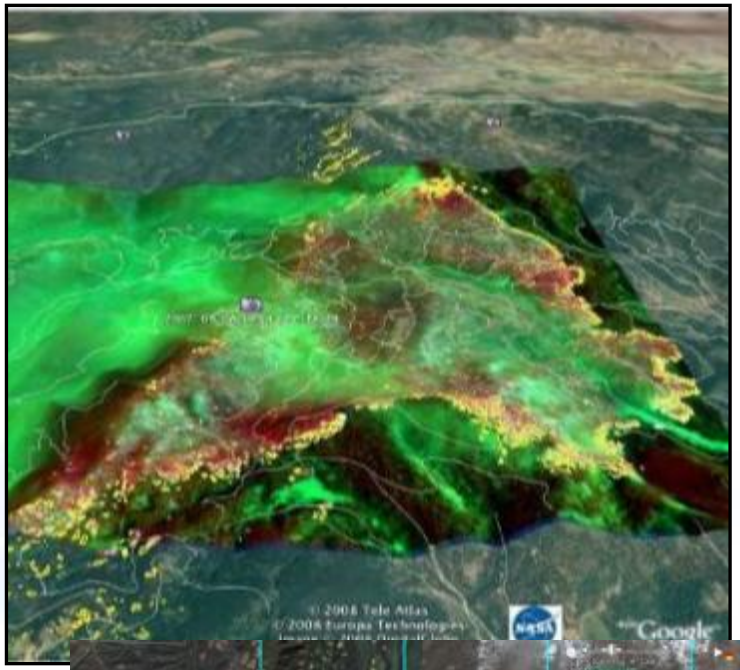
Improving sUAS Sensing of Wildfires

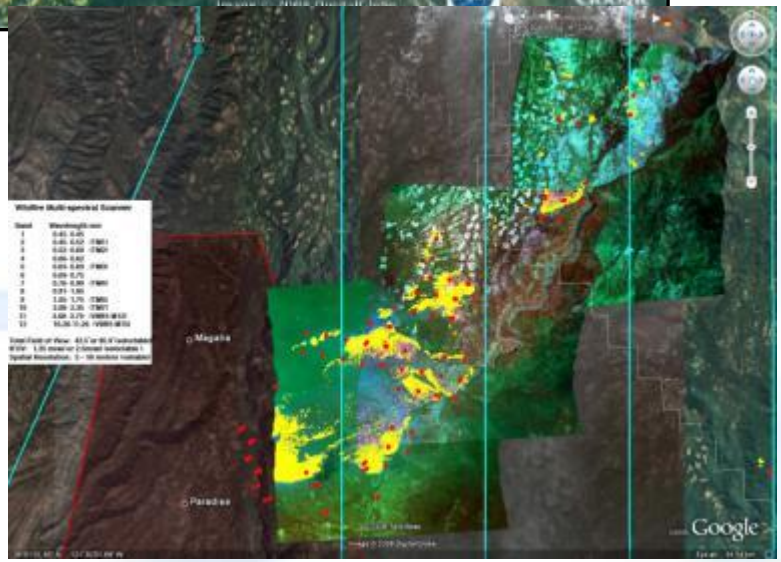
"Standard" sensors on sUAS are *NOT* optimized for high-temperature discrimination

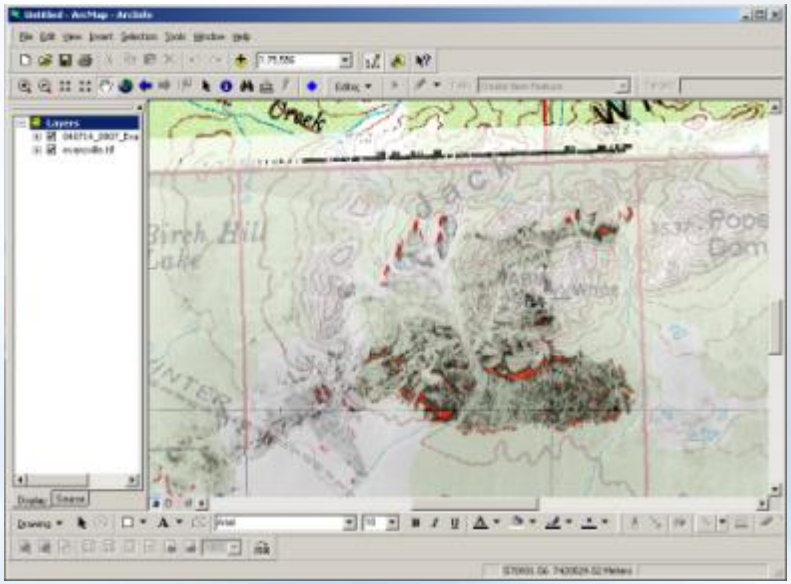
- **sUAS sensors built for large volume market (DoD), not optimized; little interest in development of small market growth-potential sensors (#'s in few 10's – 100's);**
  - **Solutions:**
    - **SBIR with relevant sensor industry**
    - **Allowances for agencies to "rebuild" commercial sensors to optimize hot target detection.**
    - **Modify platforms to allow improved sensor performance gains (make larger payload / lower power requirement systems, longer-duration flight profiles)**

Data Integration ?

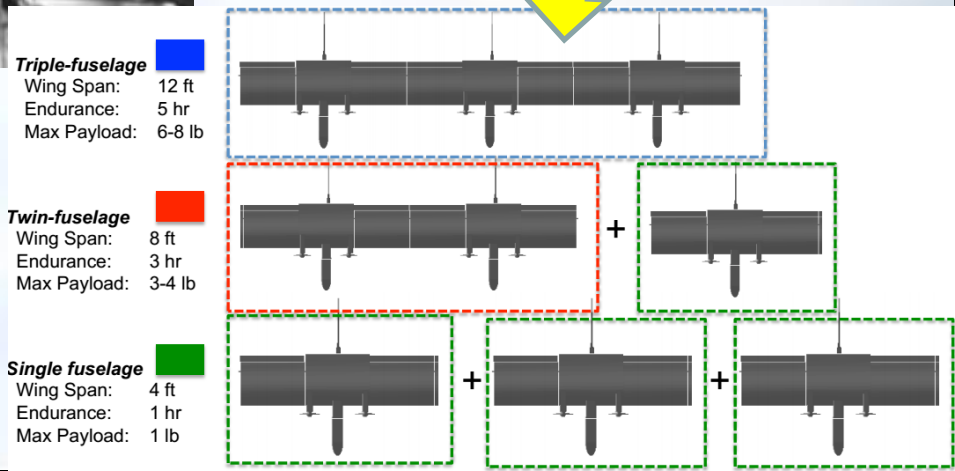
Data integration & mapping/visualization using related technologies





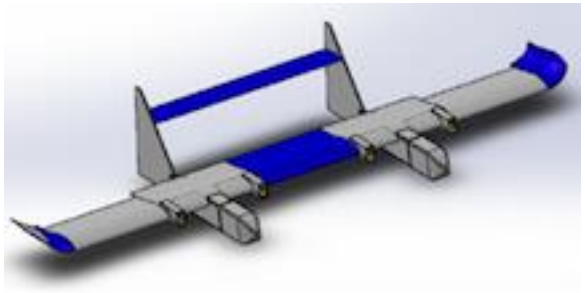


FrankenEye: Repurposing UAS for Science

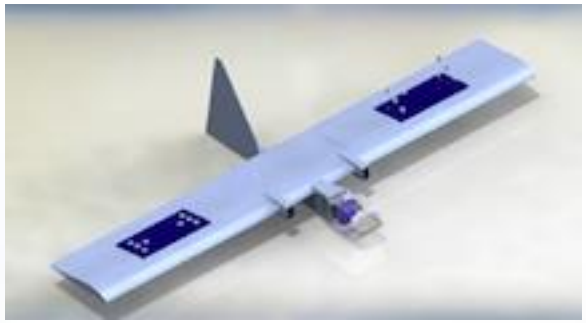


Develop multi-fuselage / multi-wing platforms from original DE to increase performance / payload characteristics.

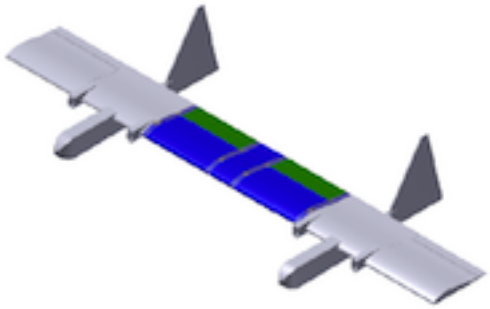
FrankenEye Student Design Competition



-Dual Body Aircraft
-3D printed winglets
-Foam Horizontal Stabilizer and Elevator
-Dual Battery design
-Custom center wing section with embedded camera



-Extended wingspan
-Vertical hover capability
-Independent image-tracking gimbal



-Twin fusilage configuration
-Custom 3D printed center section with carbon fiber spar

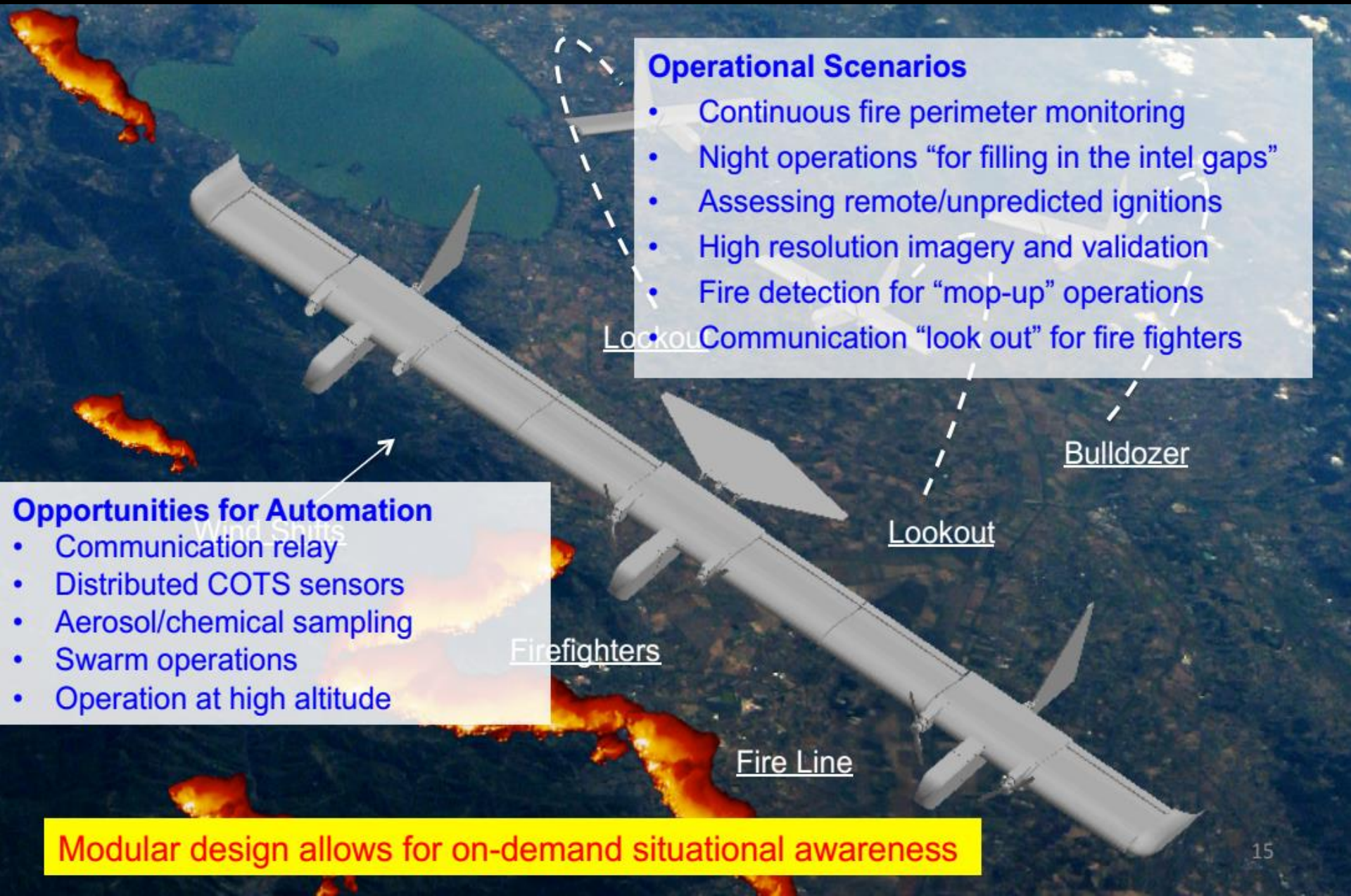
-Variable camber flaps
-Dual battery design
-VTOL capabilities

FrankenEye: Sensors and Integration

Integrated Sensor Platforms
Utilize sensor-on-a-chip technology

One aircraft -- multiple interchangeable distributed sensors

FrankenEye: Fire Monitoring Concepts



Modular design allows for on-demand situational awareness

Due Diligence For UAS Operations!

Recommendations for resource managers / incident managers and UAS operators:

- Organize and authorize a centralized coordination system;
- Implement a “grid” system to help communicate the location of daily flight plans;
- Ensure that all airspace users participate in daily calls / debriefs;
- Provide detailed information about sUAS project involvement prior to operations:
  - Location of area of operations;
  - Date of operations;
  - Maximum number of sUAS authorized to operate simultaneously;
  - Typical time and duration of flights (detailed flight plans);
  - Flight altitudes;
  - Assign POC for questions arising prior to and during field operations;
  - In-field communications information:
    - Band radio frequencies, Phone numbers’ Email addresses; Web site addresses
  - Study overview or concept of operations;
  - Capabilities for viewing the real-time location of the sUAS;
  - Establish communications protocols.

Points to Consider

- Integrating UAS into fire operations is complicated, but not impossible
- UAS ***augments*** manned aircraft capacity
  - Expands the "tool kit"
  - Transfer of technologies
- It's also about the mission objective, the sensor and related technologies
  - Sensor characteristics
  - Data and products
  - Communications; Delivery and dissemination of data/products
- UAS-derived data and intelligence can potentially increase the safety and effectiveness of firefighterS

Remarks

- **Large UAS uses on wildfires will continue to be ad-hoc (CBP support, etc.);**
- **sUAS are being evaluated, and in some cases operationalized in agencies (DOI-USGS);**
- **USFS UAS Advisory Group developing agency guidelines for UAS use on fire and other support efforts;**
- **sUAS seen as augmentation to fire aircraft operations, supplementing rotorcraft ops / and employment in hazardous conditions (night / smoke, etc.);**
- **As sUAS platforms are surplused from DoD to govt. agencies, there will be a push to utilize in disaster / wildfire support.**
- **Community needs improved small sensor capabilities for wildfire science / applications needs**

These technology adoptions will improve national wildfire decision support systems, resulting in significant time-savings in intelligence delivery, and simplifying the analysis of the data!!

Concluding Remarks

- The use of UAS to support wildfire observations must be primarily dictated by the observation objectives of the fire incident team: ***strategic or tactical observations***. These decisions then must be tempered by the capabilities of the sensors and the platforms, their ability to meet the needs of the missions, and the expected costs vs. benefit of the UAS operations.

- The way forward in UAS use for wildfire agencies is through collaboration, since no single entity currently has the assets or knowledge to support large operational UAS wildfire-imaging programs. But together, the agencies can pool assets, leverage resources, and develop standard tasking, processing, exploitation, and data dissemination procedures. They can also share awareness of capabilities with each other and work cohesively to collect the data necessary to develop UAS operating plans and procedures with the FAA.

- The USFS has created a UAS Roadmap committee to evaluate the role of UAS within the fire community to plan strategies and direction forward for eventual adaptation of UAS into operational utility.

Concluding Remarks

- UAS augments manned aircraft capacity
  - Expands the remote sensing "tool kit"
  - Transfer of technologies
- It's also about the mission objective, the sensor and related technologies
  - Sensor characteristics
  - Data and products
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- Integrating UAS into fire operations is complicated, but not impossible
  - Data and intelligence derived from UAS can potentially increase the safety and effectiveness of firefighters

Accidents Happen!!

NASA SIERRA UAS

Sooner or later this will happen…be prepared and minimize risk of events like this!!

Contacts

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vincent.g.ambrosia@nasa.gov

Everett Hinkley
ehinkley@fs.fed.us

FrankenEye Information:

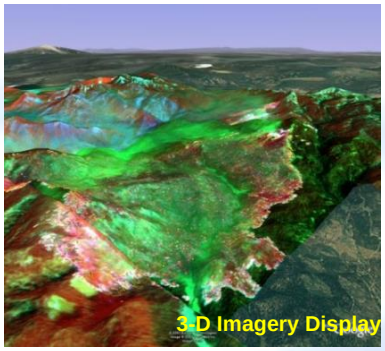
Robert Dahlgren / Kevin Reynolds
robert.p.dahlgren@nasa.gov
kevin.w.reynolds@nasa.gov

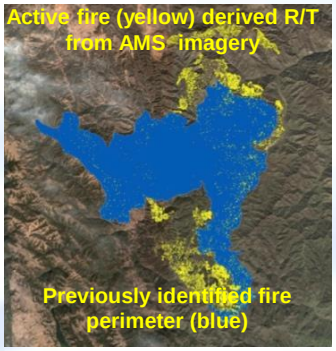
EXTRA SLIDES

NASA Ikhana UAS Fire Missions: 2006-2010

Band	Wavelength μm	
1	0.42 - 0.45	
2	0.45 - 0.52	(TM1)
3	0.52 - 0.60	(TM2)
4	0.60 - 0.62	
5	0.63 - 0.69	(TM3)
6	0.69 - 0.75	
7	0.76 - 0.90	(TM4)
8	0.91 - 1.05	
9	1.55 - 1.75	(TM5) (high gain)
10	2.08 - 2.35	(TM7) (high gain)
11	3.60 - 3.79	(VIIRS M12) (high gain)
12	10.26 - 11.26	(VIIRS M15) (high gain)
13	1.55 - 1.75	(TM5) (low gain)
14	2.08 - 2.35	(TM7) (low gain)
15	3.60 - 3.79	(VIIRS M12) (low gain)
16	10.26 - 11.26	(VIIRS M15) (low gain)

Total Field of View: 42.5 or 85.9 degrees (selectable)
IFOV: 1.25 mrad or 2.5mrad (")
Spatial Resolution: 3 – 50 meters (variable)





NASA Wildfire Support

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